An Assessment of the Impact of Climate Change on Cropping Pattern: A Case Study on Bera, Pabna

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DOI: https://doi.org/10.51244/IJRSI.2024.1108079

Received: 06 August 2024; Accepted: 13 August 2024; Published: 12 September 2024

ABSTRACT

This study shows how cropping patterns are affected due to the impact of climate change in Bera Upazila and find out the factor which is mostly responsible for this impact on cropping patterns. The impact of climate change on cropping patterns is widespread across the country. Its effect has also been observed in the cropping pattern of the Bera Upazila in Bangladesh. Rainfall anomaly index and Standardized anomaly index analysis were used to calculate rainfall and drought index. The primary data was collected from 100 respondents from 4 villages of Bera Upazila. Some data were collected through focus group discussions with farmers. In conversation with the farmers, it was revealed that many cropping patterns such as Wheat+Til+B.Aman, Chili-B. Aman have disappeared in Bera Upazila due to a lack of adequate rainfall and sometimes excessive rainfall, which causes waterlogging and makes many areas unfit for cultivation for two to three months.

In order to adapt to the impacts of climate change on planting patterns, the farmers in Bera Upazila use certain traditional methods. Change in cropping pattern, Mixed crop cultivation, and cultivating quality seeds are the considerable strategies that they follow. Mustard-Boro-Fallow, Boro-F-F, Mustard-Boro-T. Aman and Onion-Fallow-Amon are the most dominant cropping patterns now in Bera upazila. This research will contribute to our understanding of the ways in which climate change affects cropping patterns in Bera Upazila and identify the primary factors contributing to these effects.

Keywords: Climate change, Waterlogging, Rainfall anomaly index, Wheat +Til +B. Aman

INTRODUCTION

Changes in the statistical spread of weather trends that last decades to millions of years are what we call climate change. The effects of climate change on agriculture have been well studied by several nations for a variety of product kinds and yields. The current research indicates that these equatorial and subtropical nations, including Australia and Southeast Asia, are more vulnerable to the possible effects of global warming. The South Asia's monsoon rains will increase, which will cause monsoon season river flows to rise [1]. Plant growth, water equilibrium, organic matter levels, and other soil characteristics would all be affected by this temperature change. More frequent and severe storms, droughts, hurricanes, and other natural disasters are occurring in Bangladesh as a direct result of climate change. Two of the most important climatic variables are the unpredictability and uneven temporal and spatial spread of rainwater, which can lead to both storms and droughts [2]. The Intergovernmental Panel on Climate Change has projected that by 2050, wheat production in Bangladesh might decrease by 32% and rice output by 8%. Recent projections using various models with altered assumptions anticipate a 1.5 to 25.8% decrease in rice output in Australia by 2050, and a 0.4 to 5.2% decrease in rice production in Aman as a result of rising temperatures. Rice output in Boro might rise by 1.2 to 9.5% if the temperature does not reach the rice-growing threshold of 35°C [3]. As agriculture is the primary source of income for the vast majority of Bera upazila, crop cultivation in this area is very subject to climate system fluctuations. Bera upazila's farming industry and the ability to sustain the current planting pattern are likely to face serious

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue VI June 2024

challenges as temperatures increase.

Climate change will have a major impact on the food supply since farming outputs are directly dependent on weather conditions (temperature and rainfall patterns). Even a small amount of heat will cause a considerable drop in agricultural production in tropical regions. In frigid regions, a slight temperature rise may cause an increase in crop yields initially, followed by a decline. Higher temperatures will result in a significant drop in grain (rice, wheat) production worldwide [4]. There are three main growing seasons in Bangladesh, with the Boro season (winter) including the months of December through May. From November until about the middle of April, farmers can care for minor crops like wheat. However, as a result of global warming, the variability of weather patterns has become a problem for farming. Adaption strategies must be considered for agriculture's sustainability. There will be less water available for agriculture and household use in northwest Bangladesh as temperatures rise. Increased flooding and saltwater infiltration threaten the viability of current agricultural types. The inconsistency of precipitation and its uneven temporal and geographical spread are the root causes of flooding, which in turn can contribute to arid conditions and vice versa [5]. A rise in temperature, unpredictable rainfall, flooding, salinity, etc., all hurt crop yield, with water logging and drainage congestion being the biggest problems. As more and more people rely on chemical fertilizers and irrigation, the land loses its richness, wildlife, native types, aquifers, and the capacity to keep producing. In SIDR and AILA, agriculture suffered greatly, with the Sharankhola region suffering the worst damage. It has been difficult for farmers to cultivate all of their arable land. A large portion of their land remains unplanted during the winter Boro agriculture season because to salt problems, inadequate seedling supply, a lack of agricultural equipment, and a lack of low-interest or no-interest financing. Tomatoes, okra, and aroids could be grown successfully in Sharankhola's medium-saline soils if they were managed better with raised beds and mulch. The potential impacts of climate change on agricultural production, soil quality, bug populations, plant spread, and human health would likely be felt most keenly in tropical and temperate countries. Carbon dioxide (CO_2) is a gas that, contrary to popular belief, will promote vegetable development. As a consequence of climate change, Bangladesh's agrarian producing methods would be at greater risk [6]. Recent projections using various models with altered assumptions anticipate a 1.5 to 25.8% decrease in rice output in Australia by 2050, and a 0.4 to 5.2% decrease in rice production in Aman as a result of rising temperatures. Rice output in Boro might rise by 1.2 to 9.5% if the temperature does not reach the rice-growing threshold of 35°C. When the storm came, this crop was almost ready to be harvested. The Department of Agricultural Extension of Bangladesh estimates that 1.23 million tonnes of rice equivalent have been lost. The yield decline occurred across all soil conditions and potential future climates. Water availability during the wet season and scarcity during the arid season both reduce agricultural production. The water supply is a prominent worry in climate change at the current time as well as in other scenarios [7]. They also observe immature gain and twisted development as some other important difficulties that impede agricultural productivity.

The average temperature of the night time low is on the decline, while the average temperature of the daytime high is on the rise. The patterns of rainfall as they change with the seasons have also been noticed in the region under investigation. It should also be mentioned that drought is rather prevalent in the region that is prone to it because of its location and the recent Agro climatic changes. The temperature is a changeable factor that may change depending on the time of day, the season, the latitude, the altitude, the slope, the direction, the soil texture, the plant cover, and the activities that people participate in. Temperature fluctuations have a significant impact on agricultural productivity. Each kind of crop has an optimal temperature range for both its vegetative and reproductive stages of development. The investigation also found that farmers can no longer count on the timely coming of the spring rain, making it difficult to accurately predict when to plant crops. Rice is the most important grain for cultivators, but it requires a lot of water and the right climate to thrive.

The perceptions of and capacity for adapting to climate change adaptation techniques, as well as the consequences these tactics have had on rice production in the Pabna district. Natural disasters like floods, droughts, cyclones, and tsunamis have become more common and more destructive as a result of the Earth's changing environment. More erratic variations have also occurred alongside these shifts. These shifts have had a significant influence on the pattern of farming and the area used for agriculture. The early maturity rice varieties, the construction of embankments, the drought tolerance rice types, and the change of planting dates are the adaptation measures that have a modest capacity for adapting to new conditions.

Agricultural progress in Bera upazila is being stymied by a number of challenges and concerns. The present issue, which is anticipated to worsen as a result of climate change, is river floods, flash floods, river erosion, waterlogging, and drought, all of which have an impact on agricultural output and the maintenance of farming patterns. The upazila of Bera is crossed by the rivers Padma and Jamuna. As a result, Bera upazila is extremely susceptible to river damage and inundation. Nakalia and chor Panchkula experienced frequent river damage. The degradation of the Jamuna River has caused the loss of countless houses and acres of farmland. Some Bera upazila communities are particularly at risk of river erosion due to their proximity to the Padma River and the abrupt yearly rise in the river's water level, which causes flooding and waterlogging.

The purpose of this research is to examine how climate change is influencing farming production in the Bera upazila, and how local producers are adapting to this new normal. The research aims to accomplish the following. The goals of this study are to determine whether or not farming trends have changed as a result of climate change in Bera upazila, to determine which climate variables have an effect on grain output in Bera upazila, and to identify response strategies for climate change in the agricultural sector.

MATERIALS AND METHODOLOGY

The study is conducted with both primary and secondary data. Data are collected through a questionnaire survey and secondary data is collected from journals, reports, and various websites. Data were collected from 8 villages of Bera upazila through a questionnaire survey. About ten to fifteen farmers were sampled from each community, and information was gathered for this research. In order to comprehend farmers' farming methods in light of climate change, observation techniques are also employed. The farmers participated in focus groups to learn about cropping trends, changes in their vocations, how the climate affects crop productivity, and their future plans for cultivation. This study also addresses their thoughts on the challenges they experience in agriculture and how they aim to solve those problems. Data were gathered via a questionnaire from the communities' farmers who grew both rice and non-rice crops.

Table 1. Selection of the Respondents

Name of the Union	**Village**	**Number of Respondents**
Bera	Dakkhin Bongram	10
Bera	Jorda	10
Bera	Chakla	10
Bera	Boshila	10
Bera	Amaikula	15
Bera	Sanila	15
Bera	Mohonganj	15
Bera	Nakalia	15
Total	8	100

Study area: Bera Upazila is in the Pabna district and has a total land area of 248.50 square kilometers. It is situated between the coordinates 23°48' and 24°06' north latitude and 89°35' and 89°44' east longitude. It is ordered on the north by Shahjadpur and Chauhali upazila, on the south by Goalanda and Rajbari sadar upazilas, on the east by Chauhali, daulatpur, and shivalaya upazila, and on the west by Santhia and Sujanagar upazilas.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue VI June 2024

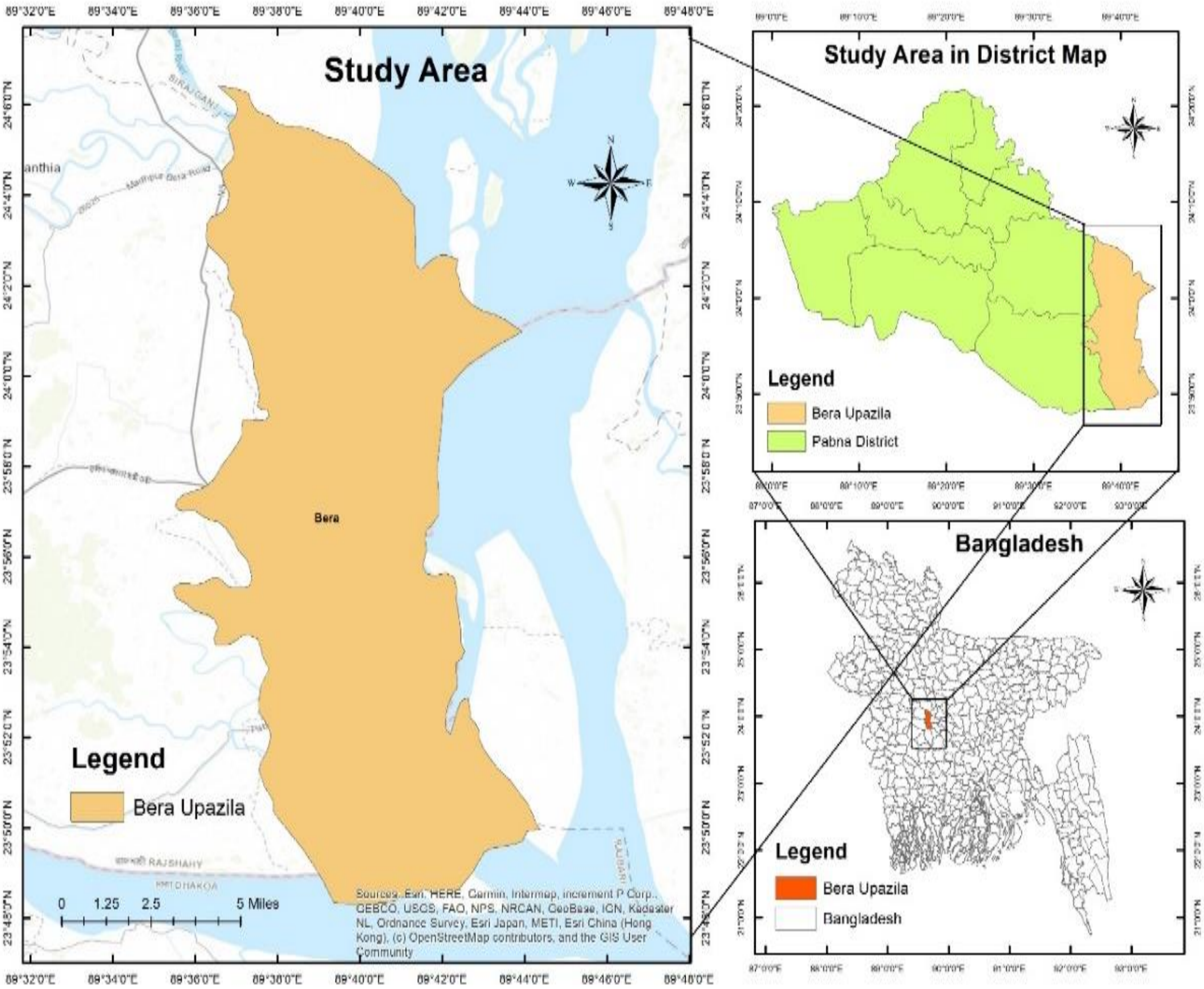

Fig. 1 Map of Study Area

Calculation of Rainfall Anomaly Index (RAI)

The rainfall anomaly index (RAI) is used to classify the positive and negative severities in rainfall anomalies.

The equation of rainfall anomaly index (RAI):

RAI= $3\times\left[\frac{N-\bar{N}}{\bar{M}-\bar{N}}\right]$ for the positive anomaly **Equation 1**

RAI= $-3\times\left[\frac{N-\bar{N}}{\bar{X}-\bar{N}}\right]$ for the negative anomaly **Equation 2**

where, N is the current monthly/seasonal/annual precipitation.

$\bar{N}$ is the average monthly/seasonal/annual precipitation of the historical series.

$\bar{M}$ is the average of the ten highest monthly/seasonal/annual precipitations.

$\bar{X}$ is the average of the ten lowest monthly/seasonal/annual precipitations.

$N - \bar{N}$ represents the positive anomaly and negative anomaly based on positive or negative values

Calculation of Standardized Anomaly Index (SAI)

The Standardized Precipitation Index (SPI) is a drought index based only on precipitation. The SPI of Bera was calculated from the precipitation record of Bera upazila.

The equation of SPI:

$$SAI = (X - \mu)/\sigma \quad \textbf{Equation 3}$$

Where, X= Current monthly/Yearly/Seasonal rainfall data

μ= Mean annual rainfall over a long period of observation

σ= Standard deviation of annual rainfall over the period of observation

RESULTS AND DISCUSSION

Cropping season and Crop production in Bera upazila

Table 2. Cropping season and crop production in Bera upazila (Source: Field Survey, 2023)

Cropping season	Time duration	Crops
Rabi	Mid-November to Mid-March	Boro rice, Onion, wheat, mustard, Lady's finger, lentils, etc.
Kharif 1	Mid-March to Mid-July	Jute, Summer vegetables, Melon, Onion, etc.
Kharif 2	Mid-July to Mid-November	Aman rice, Late summer vegetables, etc.

Onion is produced in both Rabi and kharif seasons in Bera upazila. Pabna zila is famous for cultivating onion and mustard. People said after sujanagar Bera upazila achieved 2nd/3rd position every year for onion production. Recently mustard production is also growing up in Bera upazila.

Disaster in Bera upazila

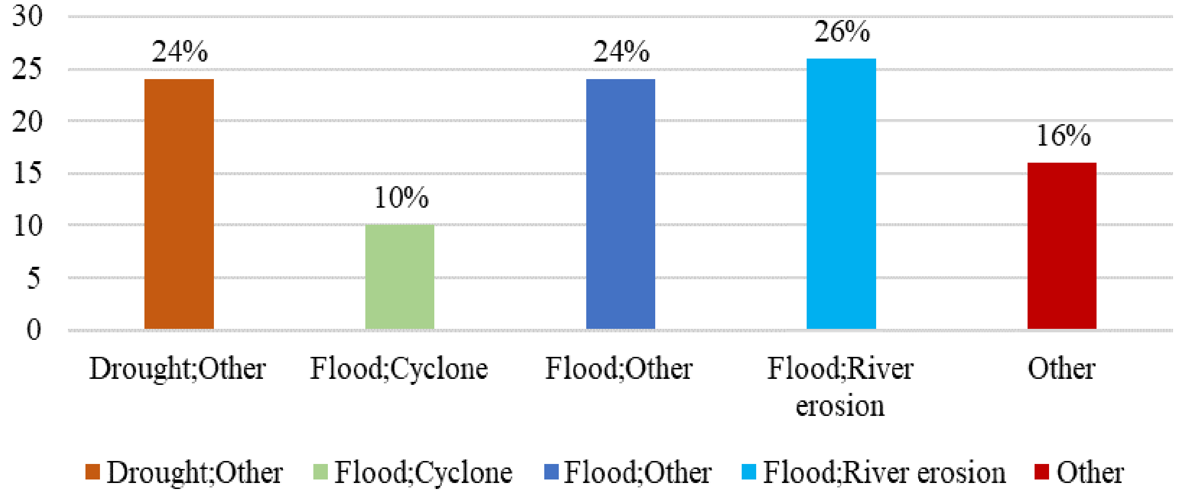

Fig. 2 Disaster in Bera upazila

In the survey, 26% of people of Nakalia and Mohonpur said Flood and river erosion occur in their villages. Though the amount of river erosion is lower than past. 24% of people of Dakshin Bangram, Jorda, and Sanila said Drought and Others. 24% said flood and others, and 10% said flood and cyclone. 16% of the respondent said other disasters. Water logging and seasonal storms also occur in Bera upazila.

Most damaging disaster on cropping pattern

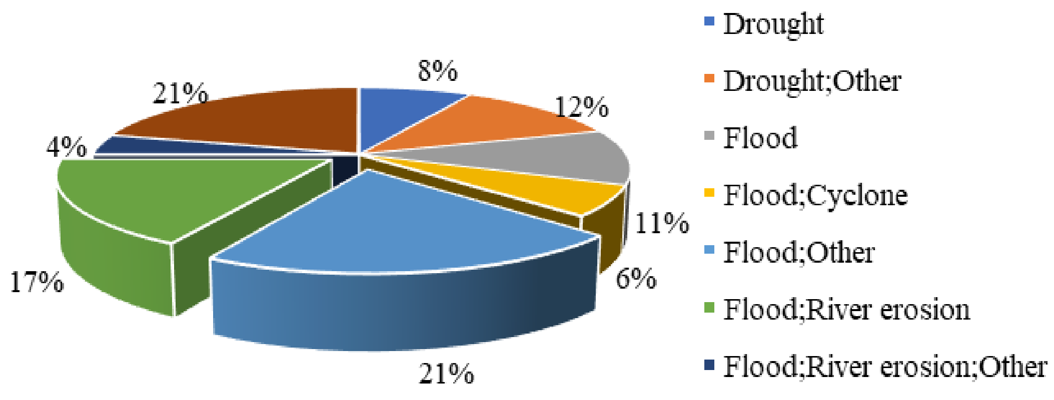

Fig. 3 Most damaging Disaster on cropping pattern

In this survey 8% of the respondent said the cropping pattern is most affected by drought. Sanila, Jorda, and Payna have irrigation problems also. About 12% of them also said drought and others such as a storm. About 11% said flood and 6% of the respondent said both flood and cyclone effect. 21% said flood and waterlogging. 17% of respondents in Nakalia and Mohonpur said their agricultural practice is mostly affected by flood and river erosion. 4% of them said flood, river erosion, and waterlogging create an impact on their agricultural practices and cropping patterns. 21% face waterlogging on their agricultural land and it creates much more impact on cropping pattern also. On the basis of the information of the respondents, it is found that the cropping pattern of Bera upazila is mostly affected by Drought, Flood, and River erosion. Waterlogging also creates an impact on the cropping pattern of Bera upazila because they cannot cultivate during the waterlogging time.

The seasonal pattern changes in Bera upazila

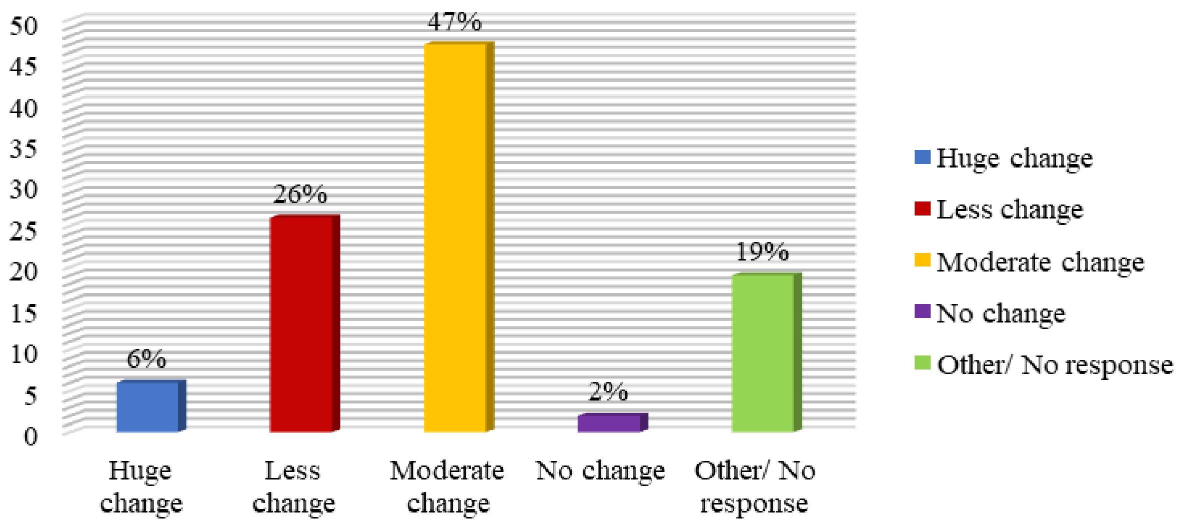

Fig. 4 Seasonal pattern changes in Bera

In the survey, it was asked how changed seasonal patterns in Bera upazila. Most of the respondents said seasonal pattern change in their locality. 47% of respondents said the seasonal pattern changes moderately while only 6% said there are huge changes in seasonal patterns. 26% of respondents said less change in seasonal patterns and 2% only said no change in seasonal pattern in their locality. 19% of respondents didn't know about the seasonal pattern and they didn't respond to the question about seasonal pattern change.

Impact of seasonal pattern changes on agricultural practice

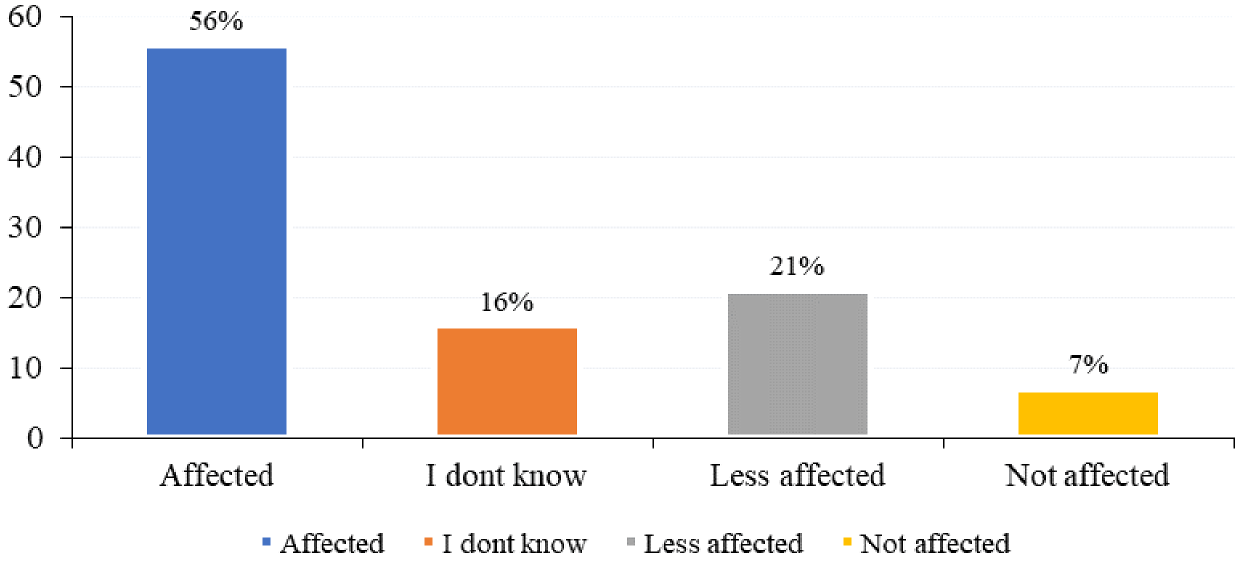

Fig. 5 Agricultural practice affected by changing seasonal pattern

56% of respondents said their agricultural practice is affected due to the impact of the seasonal pattern. Most of them said, they cannot understand the cultivation of the right crops due to the change in a seasonal pattern. That's why their crop production is reduced, unfortunately. 21% of respondents estimate their agricultural practice is less affected due to the impact of the seasonal pattern change. 16% of the respondents don't know about this matter. They didn't recognize whether their agricultural practice is affected or not. 7% of the respondents confirmed that their agricultural practice isn't affected due to the impact of seasonal pattern change.

Impact of seasonal pattern change on crop production

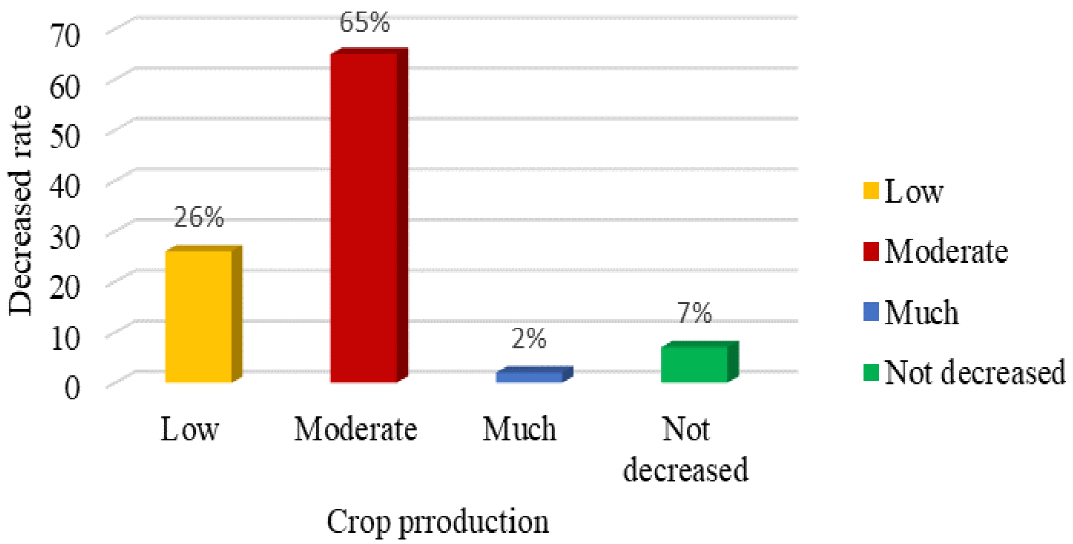

Fig. 6 Crop production decrease rate due to the changes in the seasonal pattern

65% of the respondents said the seasonal pattern changes reduce moderately their crop production. 26% of the respondents said their crop production decease at low. Only 2% of the respondents said their crop production much reduce due to the changes in seasonal pattern. About 7% of the respondents said the seasonal pattern changes create impacts on their crop production but it does not reduce their crop production or negligible amount decrease due to the changes in the seasonal pattern.

Climate Factors that are Responsible for Reducing Crop Production

Temperature

Increasing temperature is responsible for climate change. In the present world rising temperature is a common issue. Bera upazila is also affected by this issue. Some crops are damaged due to high temperature and the growth of the crops also affects by high temperature. In this graph, it shows how the temperature rise and decreases with time in Bera upazila.

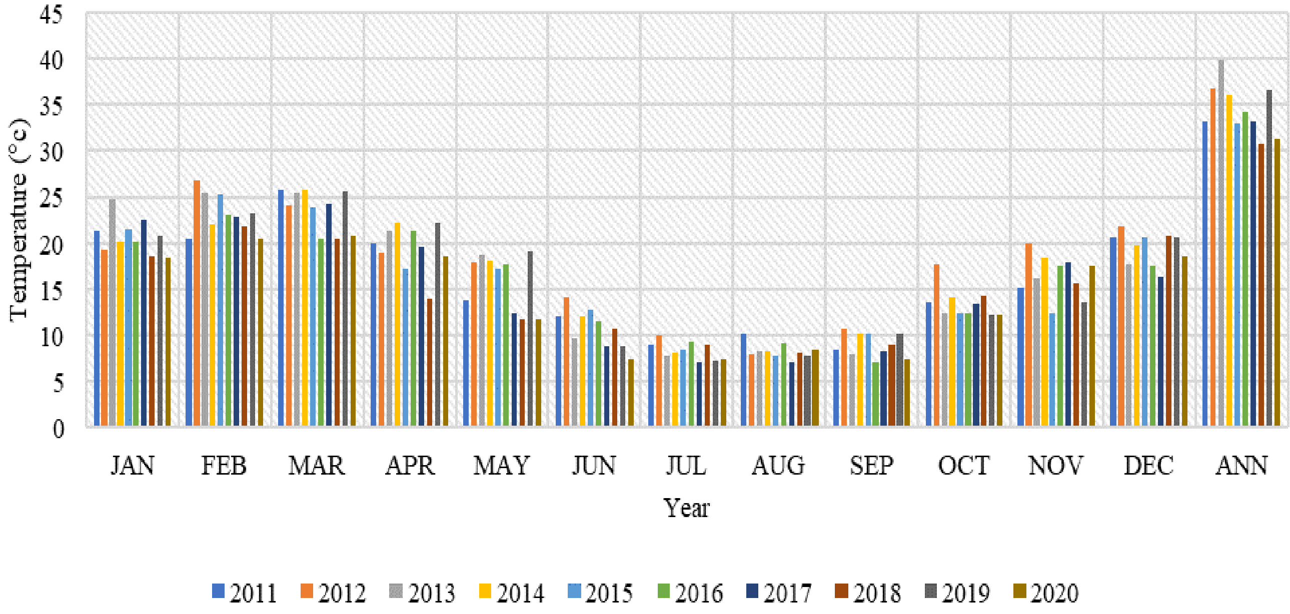

Fig. 7 Temperature (°c) data from 2011 to 2020 (Source: Nasa power)

Maximum Temperature

Maximum temperature in three monsoons from 2012 to 2021 showed how temperature varying with time.

Table. 3 Maximum temperature (°c) in three seasons (Source: NASA Power)

Year	Pre-monsoon	Monsoon	Post-monsoon
2012-2016	38.37133	33.2364	29.2285
2017-2021	40.74733	34.2252	29.9495

This table shows how the temperature rises from 2012-2016 to 2017-2021. In 2012-2016 the average temperature of the pre-monsoon season was 38.37133□c but it was 40.74733□c in 2017-2021 which means about 2□c temperature rises in the pre-monsoon season from 2012-2016 to 2017-2021. In the monsoon period, the temperature was 33.2364□c in 2012-2016 but it also rises in 2017-2021. The monsoon season of 2017–2021 had an average temperature of 34.2252°C, an increase of 0.988°C in temperature from 2012–2016 to 2017–2021. The temperature in the post-monsoon season ranged from 29.2285°c in 2012–2016 to 29.9495°c in 2017–2021.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue VI June 2024

Minimum temperature

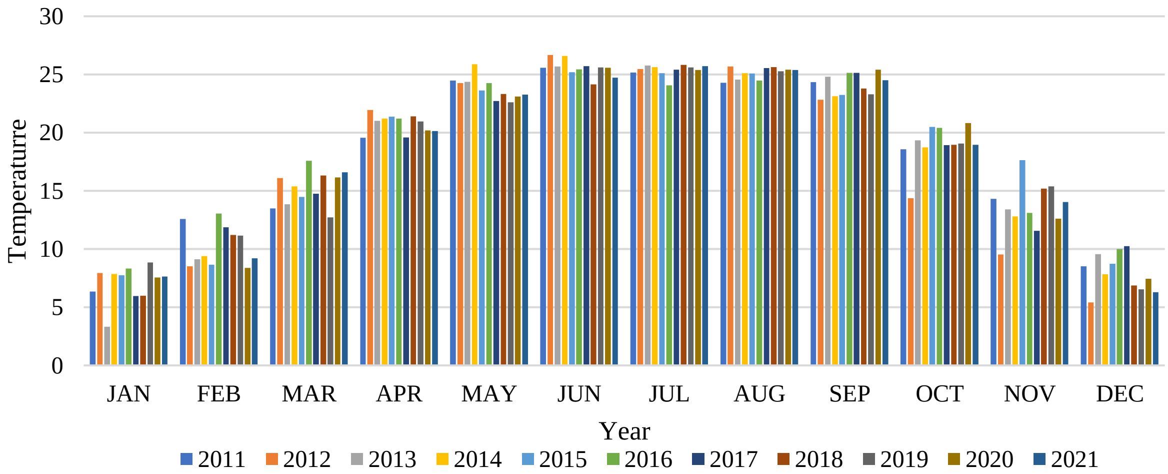

Fig. 8 Minimum temperature (□c) in Bera upazila (Source NASA Power)

This graph shows the minimum rise and fall during 20212-2021. It arises from 2013-2019 but suddenly it was falling down from 2019-2021. Very low-temperature damage crops and reduce crop production. This data is collected from NASA POWER.

In the field survey respondent said the unsuitable temperature for their crop production. 44% of the respondents said the very low temperature in the winter season affects their crop cultivation. The following impact creates by very low temperatures in the winter season are:

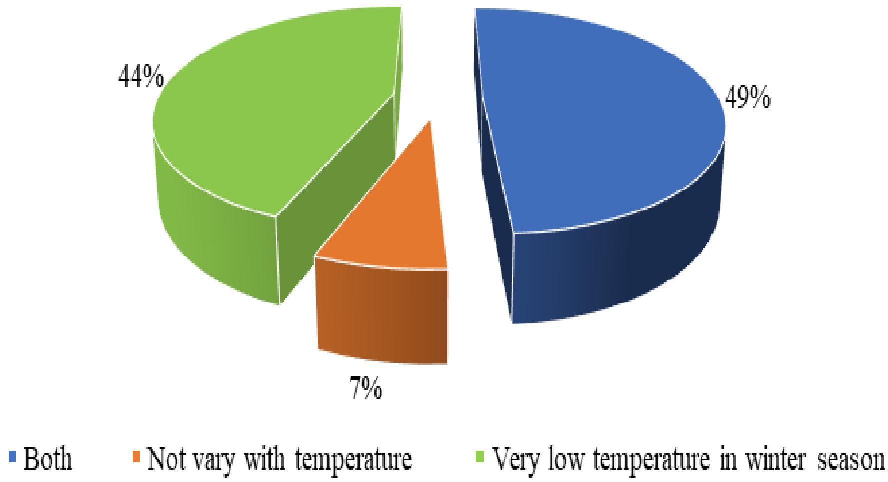

Fig. 9 Unsuitable temperature for crop production

1. Crops growth decrease
2. Don't get enough temperature for growing crops
3. Some crops damaged

49% of the respondents said both low and high temperature is unsuitable for crop cultivation. Both create an impact on crop production and crop growth. But 7% of the respondents confirmed that their cultivation does not vary with high and low temperatures.

In this 2023 winter season, mustard crops were damaged due to low temperatures in Amaikula and Boshila. Onion Crops are also damaged in some land of Jorda. They also said very high temperatures reduce crop growth and decrease crop production, which also hampered cropping pattern. The respondent of Amaikula said that low temperatures reduce mustard production this year than last year.

Irrigation system

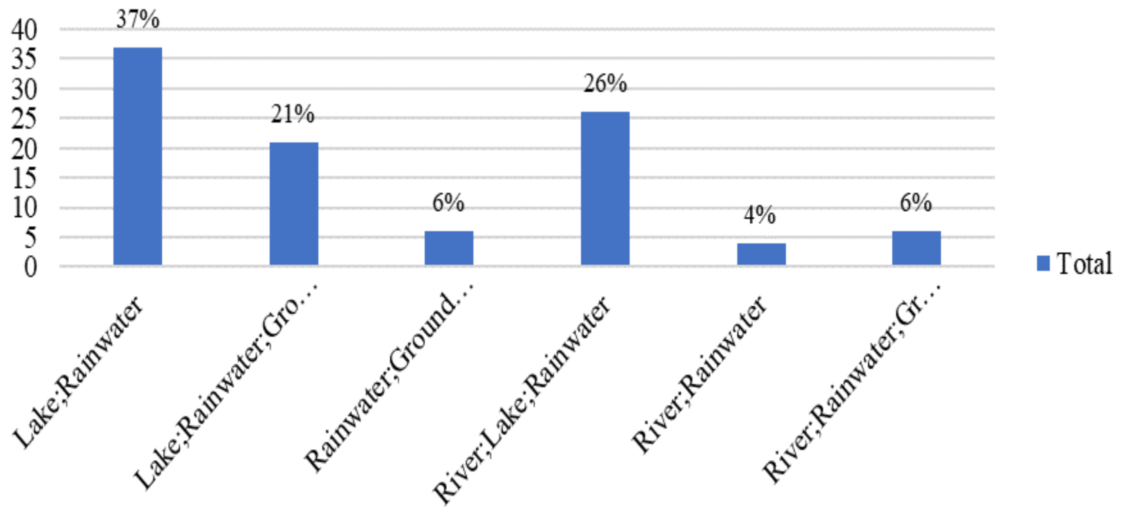

Fig. 10 Irrigation sources of the respondents

In the field survey, 37% of the respondents said their irrigation sources are lake water and rainwater. 26% of the respondents said their irrigation sources are rivers, lakes, and rainwater. 21% of the respondents said lake, rainwater, and groundwater. 6% of the respondents said rainwater and ground are their irrigation sources. 4% of the respondents said they are dependent on river water and rainwater for irrigation systems. 6% of the respondents also said they use rivers, rainwater, and groundwater for the irrigation system.

Rainfall pattern

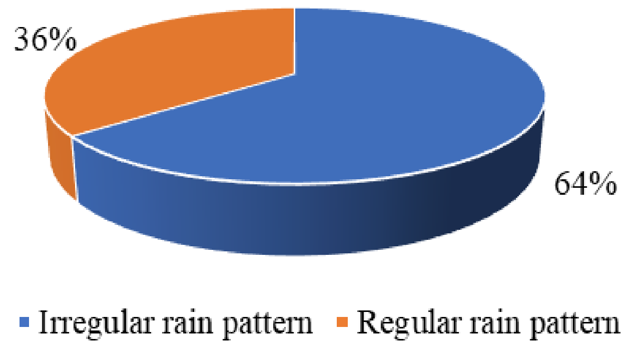

Fig. 11 Rainfall pattern in Bera upazila (Field survey)

From the field survey, 64% of the respondents said irregular rain patterns, and 36% of the respondents said regular rain patterns. They said that this type of irregular rain pattern affects their cultivation system. Some respondents said they could not maintain a regular cropping pattern due to unusual rainfall. Specially Amon rice is dependent on rainwater. If the rains don’t come in time, it impacts Amon production. Irregular rain pattern decreases Amon crops production.

Rainfall data from 2010 to 2021 of Bera upazila

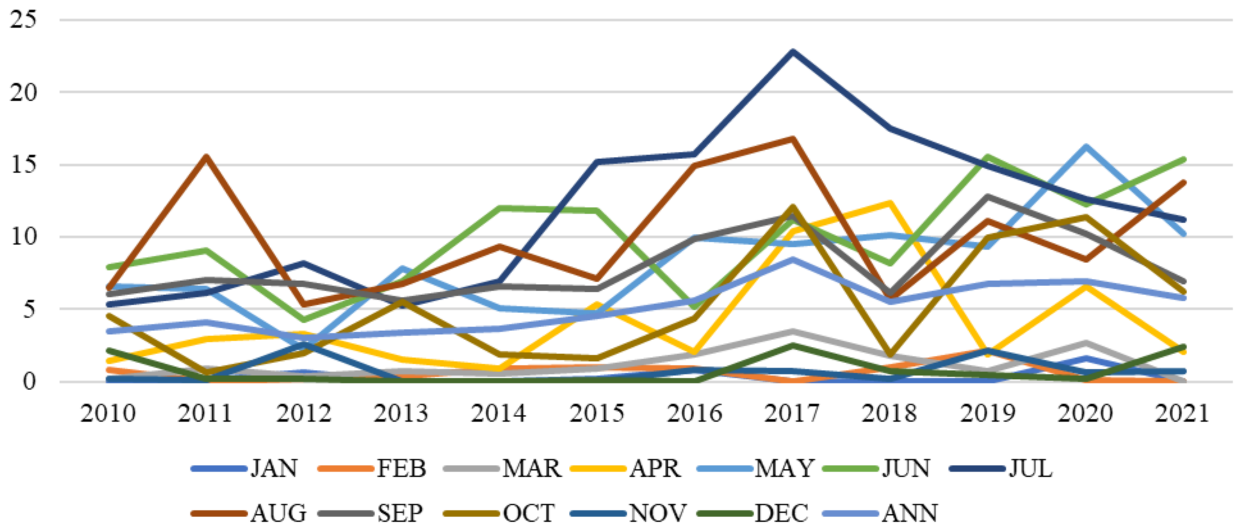

Fig. 12 Rainfall data (mm/day) from 2010 to 2022 of Bera upazila

In this graph amount of rainfall increased from 2015-2019 but it decreases in 2019-2021. From the respondent's information and this graph, it is estimated that an irregular pattern is seen in Bera upazila for the last 10 years.

Rainfall of Pre-monsoon, Monsoon, and Post-monsoon (2010-2015 & 2016-2021)

Table. 4 Rainfall data in pre-monsoon, monsoon, and post-monsoon (mm/day) (Source: NASA Power)

Year	Pre-monsoon	Monsoon	Post-monsoon
2010-2015	2.87889	6.797	0.399167
2016-2021	0.752083	11.2033	6.174444

In the late monsoon season, the amount of rainfall increased from 2010-2015 to 2016-2021. But in the post-monsoon season, generally, the amount of rainfall should be low. But in Bera upazila, this table shows the amount of rainfall in the post-monsoon season increasing day by day.

Rainfall anomaly index (RAI)

In this analysis I showed the irregularity of rainfall in Bera upazila from 1981-2021. The following table was used to classify rainfall anomaly in Bera upazila:

Table. 5 Rainfall Anomaly Index (RAI) classification to identify rainfall anomaly Source: (Falaki et al., 2013)

Rainfall Anomaly Index (RAI)	RAI range	Classification
	Above 4	Extremely humid
	2 to 4	Very humid
	0 to 2	Humid
	-2 to 0	Dry
	-4 to -2	Very dry
	Below -4	Extremely dry

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue VI June 2024

The rainfall data of Bera upazila from 1981-2021 was collected from NASA POWER station. This graph shows rainfall anomaly index of Bera upazila. Comparing with the

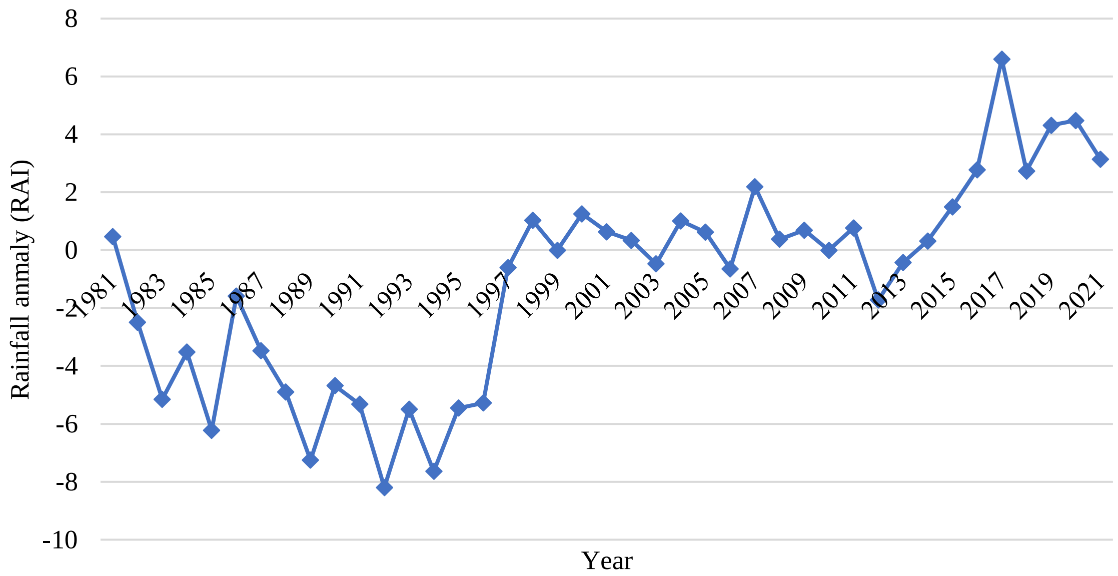

Fig. 13 Rainfall Anomaly Index for Bera upazila

Table. 3.8, this graph shows the irregularity rainfall in Bera upazila. From 1981-1995 the RAI value was -4 or above and -4 to -2. This means that the amount of rainfall in 1981-1995 was very low in Bera upazila and this was the result of extremely dry and very dry season then. 1997 was observed dry. 1998-2002 was observed humid but it was dry again in 2003,2007,2012 & 2013. The value of RAI was 0 to 2 between 2004-2006, 2008-2011 & 2014-2015. High amount of rainfall observed in 2016,2018 & 2020. The RAI value was then 2 to 4. Excessive amount of rainfall observed in the year of 2017,2019 & 2020. The RAI value was then the above 4. Through this result it is understood that there is a wide variation in rainfall of Bera upazila. Because of this rainfall anomaly the cropping pattern of Bera upazila is highly affected.

Standardized Anomaly Index (SAI)/ Drought Index

This analysis was used to calculate drought index of Bera upazila from 1981-2021. The following table was used to identify drought intensities:

Table. 6 SAI categories to identify drought intensities Source: (Al J.B., 1987)

SAI values	Category
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to +0.99	Normal
-1.0 to -1.49	Moderately dry
-1.50 to -1.99	Very dry
-2 or less	Extremely dry

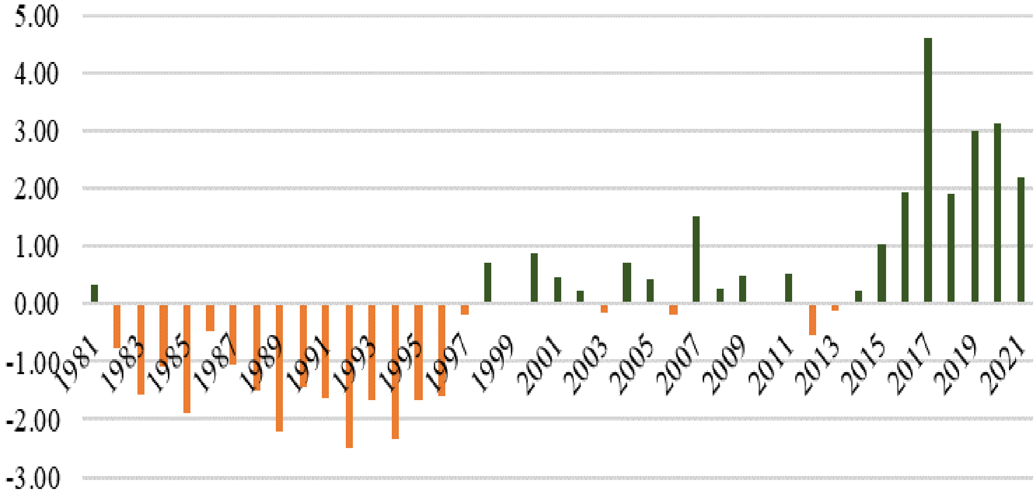

Fig. 14 Drought Index for Bera upazila

This graph was created by the formula of SAI with the help of MS Excel. The precipitation data of Bera upazila from 1981-2021 was collected from NASA POWER station. According to the Table 3.9 this graph shows, from 1982 to 1996 was dry years of Bera upazila. Extremely dry years was 1990,1992 & 1994. From 1999 to 2012 the SAI value shows normal. Extremely wet year was 2018 & 2020. This graph also shows how rainfall of Bera upazila is fluctuating from 1981 to 2021. Climate change is greatly responsible for this fluctuating. Which creates big problem for farmers to maintain a regular cropping pattern in Bera upazila.

Climate change adaptation strategy in agriculture sector

Even though the majority of Bera Upazila's respondents lack literacy, they are making an effort to adapt to how cropping patterns and crop output are being affected by climate change. The farmers in Bera Upazila employ some indigenous tactics to adjust to the effects of climate change on planting patterns. Which are:

1. Change in cropping pattern
2. Mixed crop cultivation
3. Cultivate quality seeds

Change in cropping pattern

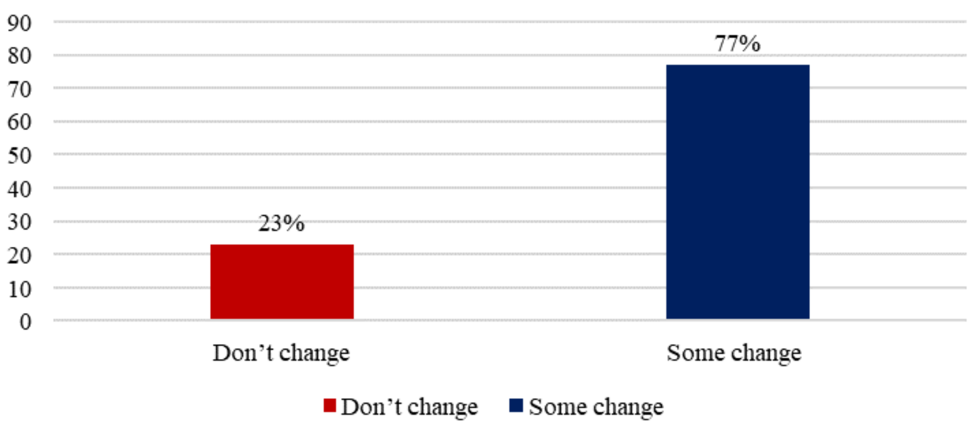

Fig. 15 Change in cropping pattern by farmers for adaptation to the impact of climate change

In order to adapt to the effects of climate change, 77% of respondents claimed they changed their cropping patterns.

Most of the use these patterns:

1. Mustard-Boro-Fallow
2. Boro-Fallow-B. Aman
3. Mustard-Boro-T. Aman
4. Onion-Jute-Fallow
5. Onion-Boro-Amon
6. Khesari/Boro-Fallow-B. Amon

In the Pabna district, Bera upazila is famous for mustard production. Most of the respondents said mustard production is more profitable than any other crop. So, most of them use Mustard-Boro-Fallow and Mustard-Boro-T. Aman cropping pattern for more profit.

Mixed crop cultivation

Boshila, Jorda, and Amaikula farmers employ mixed crop agriculture to increase productivity and address how cropping patterns are changing due to climate change. Some respondents of Boshila said, they cultivate:

1. Onion with Pea and lentils
2. Vegetables with grass on the same land.
3. Sugarcane with Onion, Til and Jute.

In FGD, farmers said mixed crop cultivation is more profitable crop cultivation. At the same time, they find two or more crops profit. Maximum respondents suggest this mixed crop cultivation for increasing crop production. To address the effects of climate change on cropping patterns, they proposed this type of crop production.

Cultivate quality seeds

Farmers of Bera upazila believed cultivation of quality seeds can improve crop production more than usual. To address the effects of climate change on agriculture, they also suggested producing high-quality seeds. They use three ways to produce good seeds:

1. At first, they select a fertile field
2. Use clean and good seed
3. Irrigate timely and use fertilizers properly

Maintain the crops from weeds, insect pests, and diseases.

CONCLUSION

This study illustrates how agricultural practices in Bera Upazila have been impacted by climate change. In the Pabna area of Bera, agriculture is heavily impacted by climate change. The majority of farmers are ignorant of how climate change is affecting agricultural lands. Climate change is causing waterlogging, droughts, and floods in this research region. Nakalia and Mohonpur are more prone to floods and waterlogging due to river erosion. Agricultural land remains waterlogged for about two to three months or sometimes more in these areas. This makes it more difficult for farmers to maintain a regular cropping pattern. As a result of the impact of climate change, the production of Aman paddy in Bera upazila has decreased slightly from earlier, besides the production of some other crops such as jute, wheat has decreased slightly from earlier. Mustard-Boro-Fallow, Boro-Fallow-Fallow, Mustard Boro-T. Aman, Onion-Jute-Fallow, and Onion-Boro-Amon cropping patterns are the present most dominant cropping pattern in Bera upazila. Bera upazila within the Pabna district is famous for mustard and onion production. So, this pattern is most dominant in Bera upazila. Earlier there were about 34 cropping patterns in Bera Upazila but now some cropping patterns have disappeared due to the effects of climate change. In certain areas of Bera Upazila, farmers cultivate mixed crops as a means of mitigating the effects of climate change on agriculture. Most of the farmers are not aware of the impact of climate change on cropping patterns and are producing fewer crops than before. Farmers need to be fully aware of climate change impacts on cropping patterns to adapt to climate change impacts in agriculture. Farmers should increase communication with Upazila Agriculture Officers to obtain updated knowledge about climate change impacts on agriculture so that they can adapt to climate change and maintain regular cropping patterns.

REFERENCES

1. IPCC, "Impacts, adaptation, and vulnerability. Report of the working group 2.," Intergovernmental Panel on Climate Change., 1997.
2. Lai et al., "“The greenhouse gas-induced climate change over the Indian Sub-continent as projected by GCM model experiments.,"” Terrestrial. Atmospheric and Oceanic Sciences, TAO, 9(iv):, pp. 663-669., 1998.
3. A. S. Islam, "National Adaptation Program of Action.," Disaster Risk Reduction., 2013.
4. N. Stern, "Report of the Stern Review: The Economics of Climate Change.," HM Treasury, London. , 2006 .
5. M. A. A. K. Z. H. S. K. Z. A. M. M. F. (Habibullah, "Assessment of Foodgrain Production Loss Due to Climate-Induced Enhanced Soil Salinity.," Vulnerability and Adaptation to Climate Change for Bangladesh, 1999.
6. Walker, B. R., & Steffen, W, "Walker, B. R., & Steffen, W. (1997, 18 December). An Overview of the Implications of Global Change for Natural and Managed Terrestrial Ecosystems," DOAJ: Directory of Open Access Journals, 1997.
7. M. A. Winston and Yunus, Climate Change Risks and Food Security in Bangladesh, 1st Edition ed., Bangladesh, 2010.